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# ENVIRONMENTAL IMPACT STATEMENT

## QUIET ENGINE PROGRAM

FEBRUARY 1971



### 1. Background

Both the Federal Government and the aviation industry are engaged in research and development programs aimed at broadening the technical base relative to aircraft noise. These programs fall into three categories:

- Reduction of noise generation at the source
- Attenuation of noise once it has been generated.
- Human response to aircraft noise

Essential to progress in noise reduction research is a basic understanding of the noise sources and characteristics. The first requirement in the area of subsonic aircraft noise, therefore, is to examine the sources of noise within an engine and the characteristics of the noise produced. The principal sources of noise in a turbofan engine are the fan, the compressor, and the jet exhaust. Each of these elements must be analyzed in detail to determine its contribution to the overall noise.

In the late 1966 the NASA Lewis Research Center conducted studies to determine the effect of turbofan cycle characteristics on engine noise levels, engine size and engine performance. The initial cycle studies provided a field of interesting cycle points around a bypass ratio of 5.0. More detailed studies to define the quiet engine were then initiated by Pratt and Whitney and by Allison, under NASA contracts, beginning in June 1967 and concluded in September 1968. These quiet engine definition studies consisted of three major tasks. The first task was a parametric study involving about 480 different engine cycle combinations. In the second task, the most promising cycles of the first task, were selected for further detailed cycle analysis. The second task also considered variations in engine configuration arrangements, such as, number of fan stages and shafts. In the third task, the design configurations were narrowed to one engine design and a complete detailed design of the engine was made. The resultant engine design information was used as the basis for requesting proposals from industry to develop an experimental quiet engine.

The program was to center on an experimental engine of approximately the same thrust as those current used on large commercial aircraft, such as the 707 and DC-8.



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## 2. Program Summary

The Quiet Engine Program was initiated with the award of a contract to the General Electric Company in July 7, 1969.

The following is the over-all Program Plan for carrying out the Experimental Quiet Engine Program by the General Electric Company for the NASA-Lewis Research Center under Contract NAS3-12430. The Program Plan sets forth major subprograms to be carried out over a time period of thirty-eight months. It is anticipated that implementation of this plan will culminate in the design, fabrication, and aero/acoustic evaluation of an experimental bypass fan engine of the 22,000 pound thrust class 15 to 20 PNdB quieter in operation than current-day or near-future aircraft propulsion systems of this size.

The Program Plan sets forth work elements that are designed to accomplish the following major program objectives:

- Demonstration of the technology and the design innovations which will reduce the production and radiation of noise in turbofan engines.

- Determination of the noise levels produced by engine which are designed for low noise output and confirmation that predicted noise reductions can be achieved.

- Acquisition of experimental acoustic and aerodynamic data for high bypass turbofan engines, which are designed for low noise output, to give a basis for correlation of acoustic theory and experiment, and to give a better understanding of the noise production mechanisms in fans, compressors, turbines, and exhaust jets.

In developing the Program Plan, consideration was given to the integrated systems approach to quiet engine propulsion systems design. Therefore, the plan calls for analytical investigations, augmented by extensive experimental investigations, necessary to develop noise tradeoff technology such that it may be used in future quiet engine designs.

A basic element of this program is the design, fabrication, and aero/acoustic evaluation of three full-scale fans, each containing low noise design features. Taken together, the three fan designs will span a range of tip speed and aerodynamic loading. The effects of these parameters (as they relate to blade passing frequency and broadband noise) will therefore also be evaluated as well as such parameters as blade number, blade-vane ratio, and casing treatment.

The three full-scale fans will be first aerodynamically tested at General Electric's full-scale fan test facility at Lynn, Massachusetts. Subsequently, these fans will be delivered to the NASA-Lewis for test in the Lewis far field acoustic test facility.

A fourth full-scale fan will be designed, fabricated, and aerodynamically tested in the Lynn facility. The design of this fan will be based upon aero/acoustic results from the previous full-scale fans, as well as results from the acoustic scale model program.

Concurrent with the full-scale fan program, the Program Plan calls for carrying out a comprehensive acoustic scale model fan evaluation program wherein unique noise reduction features are to be evaluated. The acoustic scale model fan program (approximately 50 percent scale) will employ an existing test setup at General Electric's Peebles, Ohio, far field acoustic test facility.

Also, in parallel with the full-scale and acoustic scale model fan programs, full-scale fan engine designs are to be accomplished. These designs will utilize the three basic full-scale fans as a basis and the production core components of the TF39/CF6 engine as the core engine. Following this engine design phase, hardware procurement will be accomplished, enabling the assembly of any one of the three basic fan engine configurations at any one time.

The final phase of the program will be the aero/acoustic evaluation of these full-scale bypass fan engines at General Electric's full-scale far field acoustic facility at Peebles, Ohio. During this evaluation program, it is anticipated that several acoustic modifications will be made to the basic engine configurations, based upon analysis and results from other portions of the over-all program. Acoustic treatment of the primary exhaust nozzle and extended duct acoustic treatment will also be evaluated during this full-scale test program.

2. Probable total impact of the program on the environment

The probable total impact can best be expressed in terms of the long range effect of a favorable program and not from the slight effect resulting from experimental testing (paragraph 3). As mentioned in the Program Summary noise level will be significantly reduced resulting in quieter engines for future civil aircraft.

3. Adverse environmental effects which cannot be avoided

This apparently will not be a problem. At Lewis Research Center where the noisiest part of the testing will take place (Outdoor testing of the large fans) the area outside of the Center has been thoroughly mapped and surveyed for noise levels reaching the surrounding community. Fortunately, there is a valley and dense trees between the test site and the perimeter fence. The highest noise level reaching perimeter areas is not detectably greater than the normal background noise. Testing is done between 4 A.M. and 8 A.M. Even at this quiet and early hour no complaint has been received as a result of the tests.

There will be a somewhat more difficult situation when testing begins, sometime late in CY 72, on the full-scale complete engine. This testing will be done at the Cleveland Airport next to the Lewis Research Center hanger. The idea is to make noise studies in the proper airport environment. It is unlikely that the public will even notice that testing is being done as the engine will be quieter than conventional engines, there will only be one of them compared to four on a 707. With respect to combustion product pollution, this engine will be at least as satisfactory as the criteria established for any flying engine.

4. Alternatives to the proposed action.

It would be possible perhaps to conduct these tests at a remote site. This would involve duplication of very expensive and complicated facilities, movement of required personnel, etc. This action does not appear to be justified by the small impact of this program.

5. Relationship between the local short-term uses of the environment and the maintenance and enhancement of long-term productivity.

In this case short term testing with very slight environmental effect can lead to significant long term gaims in noise reduction.

6. <u>Irreversible and irretrievable commitments of natural resources which are involved</u>.

None